

USSN 10/071,356

PATENT

-2-

In the Claims

The claims currently pending in the application are as follows:

1. (cancel)

2. (previously presented) An optical device, comprising:

a polarization-controlling reflector, said reflector converting incident-light polarization components having incident angles of polarization into reflected-light polarization components having reflected angles of polarization, said reflector having a plurality of states, and being controllable such that said reflector can be changed from one of said plurality of states to another of said plurality of states, said reflected angles of polarization having an orientation relative to said incident angles of polarization, said orientation being a function of the state of the reflector; and

a polarization-dependent optical-path device, said polarization-dependent optical-path device converting input-light polarization components that are at least partially spatially-coincident and that have been coupled into the optical device into spatially-separated input-light polarization components, said polarization-dependent optical-path device converting said spatially-separated input-light polarization components into said spatially-separated incident-light polarization components, and wherein when said reflector is in a first one of said plurality of states, said orientation is such that said polarization-dependent optical-path device causes at least a portion of the reflected-light polarization components to be out-coupled from the optical device,

wherein said polarization-dependent optical-path device includes an input polarization-dependent path splitting element, the input polarization-dependent path splitting element converting said input-light polarization components that are at least partially spatially-coincident into said spatially-separated input-light polarization components, thereby defining a branched input.

USSN 10/071,356

PATENT

-3-

3. (original) The optical device of claim 2, wherein said polarization-dependent optical-path device includes an output polarization-dependent path splitting element, and wherein prior to said polarization-dependent optical-path device converting said spatially-separated reflected-light polarization components having reflected angles of polarization into said output-light polarization components that are at least partially spatially-coincident, said output polarization-dependent path splitting element converts said spatially-separated reflected light components having reflected angles of polarization into spatially-separated reflected-light components having output angles of polarization, thereby defining a branched output, said output angles of polarization depending on the state of the reflector, wherein when said reflector is in said first one of said plurality of states, at least a portion of said output-light polarization components is out-coupled from the optical device through said branched output, and wherein the portion of said output-light polarization components that is out-coupled from the optical device through said branched output depends on the state of said reflector.

4. (original) The optical device of claim 3, wherein when said reflector is in a second one of said plurality of states, at least a portion of said output-light polarization components is out-coupled from the optical device through said branched output and at least a portion of said output-light polarization components is out-coupled from the optical device through said branched input, and wherein the portion of said output-light polarization components that is out-coupled from the optical device through said branched output and the portion of said output-light polarization components that is out-coupled from the optical device through said branched input depends on the state of said reflector.

USSN 10/071,356

PATENT

~~4~~

5. (original) The optical device of claim 3, wherein said plurality of states constitutes a continuum of states such that said optical device functions as an analog optical device, and wherein the respective portions of output-light polarization components that are out-coupled from the optical device through said
5 branched input and through said branched output is controllably variable over a continuum of said portions by selecting the state of the reflector from said continuum of states.

6. (original) The optical device of claim 3, wherein said polarization-dependent optical path device includes a polarization-dependent combiner element, and wherein after said output polarization-dependent path splitting element converts said spatially-separated reflected light components having
5 reflected angles of polarization into spatially-separated reflected-light components having output angles of polarization, the polarization-dependent combiner converts said spatially-separated reflected-light polarization components having output angles of polarization into said output-light polarization components that are at least partially spatially-coincident.

7. (previously presented) The optical device of claim 3, wherein said polarization-dependent optical path device includes a polarization-dependent combiner element, and wherein after said output polarization-dependent path splitting element converts said spatially-separated reflected light components
5 having reflected angles of polarization into spatially-separated reflected-light components having output angles of polarization, the polarization-dependent combiner converts said spatially-separated reflected-light polarization components having output angles of polarization into output-light polarization components that are orthogonal to each other.

USSN 10/071,356

PATENT

-5-

8. (original) The optical device of claim 3, wherein when said reflector is in a third one of said plurality of states, the optical device functions as a beam splitter and approximately half of the output-light polarization components are out-coupled from the optical device through said branched output and
5 approximately half of the output-light polarization components are out-coupled from the optical device through said branched input.

9. (previously presented) The optical device of claim 2, wherein the input-light polarization components coupled into the optical device and the reflected-light polarization components out-coupled from the optical device at least partially share a common optical path within the optical device.

10. (previously presented) The optical device of claim 2, wherein the input-light polarization components coupled into the optical device propagate along at least one input optical path of the optical device and the reflected-light polarization components are out-coupled from the optical device via at least one
5 output optical path of the optical device, the at least one output optical path being distinct from the at least one input optical path.

11. (original) An optical device comprising:
a polarization-controlling reflector, said reflector converting a first set of spatially-separated incident-light polarization components having incident angles of polarization into a first set of spatially-separated reflected-light polarization
5 components having reflected angles of polarization and converting a second set of spatially-separated incident-light polarization components having incident angles of polarization into a second set of spatially-separated reflected-light polarization components having reflected angles of polarization, the incident angles of polarization of said first set of incident-light polarization components being
10 different from the incident angles of polarization of said second set of incident-

USSN 10/071,356

PATENT

-6-

light polarization components, the reflected angles of polarization of said first set of spatially-separated reflected-light polarization components being different from the reflected angles of polarization of said second set of spatially-separated reflected-light polarization components, said reflector having a plurality of states and being controllable such that said reflector can be changed from one of said plurality of states to another of said plurality of states, the reflected angles of polarization having orientations relative to their respective incident angles of polarization, said orientations being a function of the state of the reflector; and

15 a polarization-dependent optical-path device having at least a first input port, a first output port, a second input port and a second output port, said polarization-dependent optical-path device converting a first set of input-light polarization components that are at least partially spatially-coincident and that have been coupled into the first input port of the optical device into a first set of spatially-separated input-light polarization components and converting a second

20 set of input-light polarization components that are at least partially spatially-coincident and that have been coupled into the second input port of the optical device into a second set of spatially-separated input-light polarization components, said polarization-dependent optical-path device converting said first set of spatially-separated input-light polarization components into said first set of spatially-separated incident-light polarization components and converting said

25 second set of spatially-separated input-light polarization components into said second set of spatially-separated incident-light polarization components, and wherein when said reflector is in a first one of said plurality of states, said orientation is such that said polarization-dependent optical-path device causes at least a portion of said first set of reflected-light polarization components to be

30 out-coupled from the optical device through said first output port.

35

USSN 10/071,356

PATENT

-7-

12. (original) The optical device of claim 11, wherein when said reflector is in said first one of said plurality of states, said orientation is such that said polarization-dependent optical-path device causes at least a portion of said second set of reflected-light polarization components to be out-coupled from the optical device through said second output port.

13. (original) The optical device of claim 12, wherein when said reflector is in a second one of said plurality of states, said orientation is such that said polarization-dependent optical-path device causes at least a portion of said first set of reflected-light polarization components to be out-coupled from the optical device through said second output port.

14. (original) The optical device of claim 12, wherein when said reflector is in a second one of said plurality of states, said orientation is such that said polarization-dependent optical-path device causes at least a portion of said second set of reflected-light polarization components to be out-coupled from the optical device through said first output port.

15. (original) The optical device of claim 11, wherein said polarization-dependent optical-path device includes an input polarization-dependent path splitting element, the input polarization-dependent path splitting element converting said first set of input-light polarization components that are at least partially spatially-coincident into said first set of spatially-separated input-light polarization components and converting said second set of input-light polarization components that are at least partially spatially-coincident into said second set of spatially-separated input-light polarization components, said first and second sets of said spatially-separated input-light polarization components propagating along a common optical path of the optical device from the first input port.

USSN 10/071,356

PATENT

-8-

16. (original) The optical device of claim 11, wherein said polarization-dependent optical-path device includes an input polarization-dependent path splitting element, the input polarization-dependent path splitting element converting said first set of input-light polarization components that are at least partially spatially-coincident into said first set of spatially-separated input-light polarization components and converting said second set of input-light polarization components that are at least partially spatially-coincident into said second set of spatially-separated input-light polarization components, said first set of said spatially-separated input-light polarization components propagating along a first optical path of the optical device from the first input port and said second set of said spatially-separated input-light polarization components propagating along a second optical path of the optical device from the first input port, the first optical path being distinct from the second optical path.

17. (original) The optical device of claim 11, wherein said polarization-dependent optical-path device includes an output polarization-dependent path splitting element, and wherein prior to said polarization-dependent optical-path device converting said first and second sets of spatially-separated reflected-light polarization components into said first and second sets, respectively, of output-light polarization components that are at least partially spatially-coincident, said output polarization-dependent path splitting element converts said first set of spatially-separated incident-light components having incident angles of polarization into a first set of spatially-separated reflected-light components having reflected angles of polarization that are different from said incident angles of polarization of said first set of spatially-separated incident-light components, and converts said second set of spatially-separated incident-light components having incident angles of polarization into a second set of spatially-separated reflected-light components having reflected angles of polarization that are different from said incident angles of polarization of said second set of spatially-separated incident-light components, said reflected

USSN 10/071,356

PATENT

-9-

angles of polarization of said first and second sets of spatially-separated reflected-light polarization components depending on said state of the reflector, wherein when said reflector is in said first one of said plurality of states, at least a portion of said first set of output-light polarization components is out-coupled from the optical device through said first output port.

18. (original) The optical device of claim 17, wherein when said reflector is in said first one of said plurality of states, said orientation is such that said polarization-dependent optical-path device causes at least a portion of said second set of output-light polarization components to be out-coupled from the optical device through said second output port.

19. (original) The optical device of claim 18, wherein when said reflector is in a second one of said plurality of states, said orientation is such that said polarization-dependent optical-path device causes at least a portion of said first set of output-light polarization components to be out-coupled from the optical device through said second output port.

20. (original) The optical device of claim 18, wherein when said reflector is in a second one of said plurality of states, said orientation is such that said polarization-dependent optical-path device causes at least a portion of said second set of output-light polarization components to be out-coupled from the optical device through said first output port.

21. (cancelled)

USSN 10/071,356

PATENT

-10-

22. (original) An integrated optical device comprising:

at least a first input port;

at least a first output port;

5 a substantially non-reciprocal directional stage comprising one or more elements that are configured to operate on polarization components of light, the directional stage receiving light from at least the first input port, the received light having polarization components, the directional stage controlling a path of propagation of the received light through the directional stage by operating on the polarization components of the received light;

10 a reflective element having a plurality of states such that light impinging on the reflective element is reflected by the reflective element with a polarization that depends on the state of the reflective element; and

a polarization stage interposed between the directional stage and the reflective element, the polarization stage directing the polarization components of light propagating through the directional stage onto the reflective element by
15 operating on the polarization components of the light received by the polarization stage from the directional stage, and wherein the polarization stage directs light components reflected from the reflective element into the directional stage with a polarization that depends on the state of the reflective element to enable the
20 directional stage to control the path of propagation of the reflected light based on the polarization of the reflected light components.

23. (original) The integrated optical element of claim 22, wherein when the reflective element is in a first one of said plurality of states, at least a fraction of the reflected light is out-coupled from the integrated optical device through the first output port and at least substantially none of the reflected light is output
5 from the integrated optical device through the first input port.

USSN 10/071,356

PATENT

-11-

24. (original) The integrated optical element of claim 23, further comprising a second output port, and wherein when the reflective element is in a second one of said plurality of states, at least a fraction of the reflected light is out-coupled from the integrated optical device through the second output port and at least substantially none of the reflected light is output from the integrated optical device through the first input and first output ports.

25. (original) The integrated optical element of claim 23, further comprising a second input port, wherein light received by said substantially non-reciprocal directional stage from the second input port has polarization components, the directional stage controlling the path of propagation of the light received from the second input port through the directional stage by operating on the polarization components of the light received through the second input port, and wherein the light received through the second input port is reflected by the reflective element with a polarization that depends on the state of the reflective element, and wherein when the reflective element is in a second one of said plurality of states, at least a fraction of the reflected light corresponding to light received through the first input port is out-coupled from the integrated optical device through the second output port and at least a fraction of the light received through the second input port is out-coupled through the first output port.

26. (original) The integrated optical device of claim 22, wherein the directional stage comprises one or more walk-off crystals and one or more Faraday rotators for manipulating the polarization components of the light received through the first input port.

USSN 10/071,356

PATENT

-12-

27. (original) The integrated optical device of claim 22, wherein the polarization stage comprises at least one birefringent element that directs polarization components of light received from the directional stage onto the reflective element in a manner dictated by the polarization components of the received light and by a configuration of said at least one birefringent element, and wherein the polarization stage directs light reflected from the reflective element into the directional stage in a manner dictated by the polarization components of the reflected light and by the configuration of said at least one birefringent element, thereby causing the polarization stage to function as a polarizing beam splitter that directs reflected light into an appropriate side of the directional stage.

28. (original) The integrated optical device of claim 22, wherein the reflective element is a liquid crystal cell.

29. (cancelled)

USSN 10/071,356

PATENT

-13-

30. (previously presented) A method for operating on light, the method comprising:

- 5 providing an optical device comprising a polarization-dependent optical path device and a controllable reflective element that has a plurality of states, said polarization-dependent optical-path device including an input polarization-dependent path splitting element, the input polarization-dependent path splitting element spatially separating said input-light polarization components to obtain said spatially-separated input-light polarization components, thereby defining a branched input;
- 10 coupling input light into the optical device;
- using the polarization-dependent optical path device to separate the input light into spatially-separated input-light polarization components;
- using the polarization-dependent optical path device to provide the polarization components with incident angles of polarization and to direct the polarization components onto the reflective element;
- 15 placing the reflective element in one of said plurality of states, wherein the reflective element reflects the input-light polarization components incident thereon, thereby producing reflected-light polarization components having reflected angles of polarization, the reflected angles of polarization depending on the state of the reflective element; and
- 20 using the polarization-dependent optical path device to combine the reflected-light polarization components, the combined reflected-light polarization components being out-coupled from the optical device.

USSN 10/071,356

PATENT

-14-

31. (original) The method of claim 30, wherein said polarization-dependent optical-path device includes an output polarization-dependent path splitting element, said output polarization-dependent path splitting element converting said reflected-light polarization components having reflected angles of polarization into spatially-separated reflected-light polarization components having reflected angles of polarization, thereby defining a branched output, said reflected angles depending on the state of the reflective element, wherein when said reflector is in a first one of said plurality of states, at least a portion of said combined reflected-light polarization components is out-coupled from the optical device through said branched output, and wherein the portion of the out-coupled light components that is out-coupled from the optical device through said branched output depends on the state of said reflector.

32. (original) The method of claim 31, wherein when said reflective element is in a second one of said plurality of states, at least a portion of the combined reflected-light polarization components is out-coupled from the optical device through said branched output and at least a portion of said output-light polarization components is out-coupled from the optical device through said branched input, and wherein the portion of the polarization components that is out-coupled from the optical device through said branched output and the portion of the polarization components that is out-coupled from the optical device through said branched input depends on the state of said reflective element.

USSN 10/071,356

PATENT

-15-

33. (original) The method of claim 31, wherein said plurality of states constitute a continuum of states such that said optical device functions as an analog optical device, and wherein the respective portions of polarization components that are out-coupled from the optical device through said branched input and through said branched output are variable over a continuum of said portions by controllably selecting the state of the reflective element from said continuum of states.

5